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Report to the Committee on National Security, House of Representatives

April 1998

AIM-9X ACQUISITION

Missile Risk Reduction Underway But System Production Plans Need to be Reexamined

GAO

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National Security and
International Affairs Division

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April 28, 1998

The Honorable Curt Weldon
Chairman, Subcommittee on Military
Research and Development
Committee on National Security
House of Representatives

Dear Mr. Chairman:

As you requested, this report addresses the development status of the AIM-9X missile program and our concerns about the testing and production of all elements of the AIM-9X weapon system.

We are sending copies of this report to the other defense committees and subcommittees; the Secretaries of Defense, the Air Force, and the Navy; the Director, Office of Management and Budget; and other interested parties. We will also make copies available to others upon request.

Please call me at (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report were William Graveline, Matthew Mongin, and Gerald Wood.

Sincerely yours,

Louis J. Rodrigues
Director, Defense Acquisitions Issues

Executive Summary

Purpose

The Navy and the Air Force are jointly developing the AIM-9X short-range air-to-air missile to replace the AIM-9M missile. The Chairman, Subcommittee on Military Research and Development, House Committee on National Security, requested that GAO provide an independent assessment of the program's status. Accordingly, this report discusses the (1) services' efforts to reduce missile development risk, (2) missile program's plan to transition from development to production, and (3) importance of separately managed but essential supporting systems.

Background

The U.S. Navy-designed and -built AIM-9 Sidewinder family of air-to-air missiles has protected U.S. fighter pilots for over 40 years. These short-range missiles are carried on all tactical fighter aircraft and are used when target aircraft are too close for mid-range missiles to be effective. The current missile is the AIM-9M, which evolved in 1978, but this missile is becoming outdated. In April 1996, the Air Force Chief of Staff testified before Congress that U.S. pilots carrying the AIM-9M have the fourth best short-range missile in the world. According to the Naval Intelligence Service, modern missiles, such as the Russian AA-11 and Israeli PYTHON 4, both with their helmet-mounted cueing/targeting systems, are very capable. The services have for several years sought to provide a better short-range missile system for U.S. forces. Before beginning the AIM-9X program, the services considered acquiring a modern foreign missile but, after a lengthy study, concluded that none met all of the U.S. requirements.

The AIM-9X missile system is to be a highly maneuverable missile, with full day and night capability and helmet-mounted cueing capability. The missile is designed to have increased resistance to countermeasures and improved target acquisition capability over the AIM-9M. It will have a new infrared seeker, sophisticated target tracking software to interpret what the seeker sees, a streamlined missile body, and thrust-aided steering for improved maneuvering. It is to be carried on all U.S. fighter aircraft, including the F-22. The AIM-9X helmet-mounted cueing system will allow U.S. pilots to aim the missile by turning their heads and looking at the target. Importantly, however, the helmet-mounted cueing system is currently being developed under a separate, parallel program from the missile. Another effort is developing the necessary hardware and software modifications to integrate the missile and helmet into the aircraft.

In late 1996, after an 18-month competitive demonstration and validation program, Hughes Missile Systems Company (now the Raytheon Corporation) was selected to be the prime contractor for the AIM-9X

missile. Hughes has total missile performance responsibility, including development, production, and lifetime maintenance support. The engineering and manufacturing development effort began in January 1997 and is scheduled to end in 2001. The services plan to buy a total of 10,000 missiles at an average unit production cost of $264,000 (then-year dollars).

Results in Brief

The AIM-9X missile program includes many initiatives to reduce the risk of technical, cost, and schedule problems. It uses many existing subsystems, components, and items not requiring development, and government and contractor technical experts have joined together in integrated product teams. In addition, the services conducted a competitive demonstration and validation of new technologies to reduce technical risk.

GAO is concerned, however, about two situations. First, that the plan to start missile low-rate initial production about 1 year before completing development flight testing and before operational testing of production representative missiles will risk later discovery of technical or operational suitability problems. Accordingly, at this critical juncture, Department of Defense (DOD) decisionmakers will not have enough verifiable information on the system's key performance parameters in an operational environment to make an informed production decision.

Second, GAO is concerned that the helmet-mounted cueing system is being developed under a separate program from the missile even though U.S. fighter pilots need both the AIM-9X missile and the helmet-mounted cueing system to ensure that they can prevail in air-to-air combat against modern threat missiles. While the separate development programs are being coordinated, there is no requirement that the missile, helmet, and aircraft modifications be thoroughly and realistically tested and evaluated together as a system of systems prior to initiating AIM-9X missile production. Until the weapon system is tested and evaluated using production representative missiles and helmets, DOD decisionmakers will not have information on whether the AIM-9X weapon system's key performance parameters—such as the ability to acquire, track, and fire on targets over a wider area than the AIM-9M—are achievable. Further, if all elements of the system are not produced and deployed together, the AIM-9X may not be able to prevail in aerial combat against modern threat missiles.

Principal Findings

Missile Development Program Uses Risk Reduction Strategies

The services plan to reduce technical risk in developing the AIM-9X missile by using several existing subsystems from the AIM-9M, including the warhead, rocket motor, and fuze. The Hughes' AIM-9X design also includes nondevelopmental items—such as the airframe and engine control system—which were developed and tested previously by the Air Force. To ensure low technical risk for the sensor, guidance and control subsystem, and other critical subsystems, the services conducted an 18-month competitive demonstration and validation program. Because of this program's success, both Hughes and the program manager consider the AIM-9X missile's overall technical risk to be low as it enters engineering and manufacturing development. There are some individual areas of technical risk, now considered to be moderate to low, that could pose development problems. For example, since target acquisition and tracking can take place in the presence of countermeasures, the development of the guidance and control software is a complex and challenging task. Program and contractor officials understand these risks and believe adequate time and resources are available within the program to resolve any problems that may emerge during development.

The effectiveness of the program's efforts to reduce technical, cost, and schedule risk will not be known for at least another year when the missile design is to be finalized and flight testing is underway. If the program remains on the planned schedule, both program and contractor managers believe any remaining development risk will be well understood. At that time, the program's progress and readiness to begin low-rate initial production can be considered, together with the services' fiscal year 2000 budget request for initial production funds.

Missile Low-Rate Initial Production to Start Prematurely

Low-rate initial production of the AIM-9X missile is planned to start in March 2000, before sufficient testing is accomplished. Production would begin before demonstration by realistic flight testing that the AIM-9X system's key performance parameters are achievable. The services plan to begin production about 1 year prior to the completion of developmental flight testing. All of the flight tests to be conducted before the missile low-rate initial production decision, including those to be conducted as part of the preliminary operational testing, will use engineering development missiles. After the initial production decision, additional

developmental flight tests and all of the operational testing with production representative missiles—which are development missiles but very close in physical configuration and performance to production missiles—are to be conducted for the following 2 years. Developmental flight tests will not be complete and no results of operational testing of production representative missiles will be available before the low-rate initial production decision. Accordingly, the test results may not accurately reflect the capabilities of the final production configuration of the system. Making a production decision on the basis of such incomplete testing risks the discovery of technical problems during later developmental and operational testing that may require costly design changes after production begins.

AIM-9X System of Systems Needs to Be Tested, Produced, and Deployed Together

All elements of the AIM-9X weapon system—the missile, the helmet, and associated aircraft modifications—must be present and working together for the system to prevail against modern missile threats. The services are trying to closely coordinate the separate development of the AIM-9X missile, the helmet-mounted cueing system, and associated hardware and software modifications to their aircraft. However, DOD does not require that production representative versions of all three elements of the weapon system be tested together as a single system of systems prior to the AIM-9X missile's low-rate initial production decision. Without this testing, DOD will not have data to determine the extent to which the AIM-9X weapon system's key performance parameters are achievable.

In addition, although the services have approved an AIM-9X missile production plan and made long-term funding commitments to buy the missiles, there are no approved production plans or funding for the helmet or associated aircraft modifications. The helmet program manager told us the individual aircraft program offices, such as the F-15 and F-16, are expected to separately budget for and buy helmets and modification kits consistent with their other aircraft improvement plans. If DOD is making a commitment to the AIM-9X system, that commitment needs to extend beyond the missile and include the helmet cueing system and the associated aircraft modifications. Navy and Air Force officials have stated that their fighters need both the AIM-9X missile and helmet-mounted cueing system to ensure that they can prevail against modern threat missiles.

Recommendations

GAO recommends that the Secretary of Defense direct the Secretaries of the Navy and the Air Force to revise the AIM-9X missile's acquisition strategy and production plan to allow for all developmental flight testing and enough operational testing of the AIM-9X missile, helmet, and aircraft modifications to be accomplished using production representative hardware and software to demonstrate that the AIM-9X weapon system can meet its minimum performance requirements before low-rate initial production begins. GAO also recommends that they achieve a single, coordinated production, deployment, and funding plan for the AIM-9X missile, helmet-mounted cueing system, and associated aircraft modifications at the low-rate initial production decision.

Agency Comments and GAO Evaluation

In response to a draft of this report, DOD disagreed with most of GAO's recommendations. DOD believes that the risks associated with AIM-9X missile development are well characterized and mitigation plans are in place to address the risks. Accordingly, DOD believes current test plans are adequate to provide an informed decision at the low-rate initial production milestone. DOD agrees that all elements of the AIM-9X weapon system are needed for the full capability of the system to be realized. However, because of the current disadvantage warfighters face, DOD states that it is unwilling to delay missile production should technical problems with the helmet occur. DOD stated the AIM-9X missile by itself offers a significant improvement over the current operational system that should not be withheld. Finally, DOD pointed out that while there is no formal requirement to tie these programs together, it agreed that it is extremely important to achieve an integrated system as soon as possible and will continue to emphasize coordination and review efforts.

GAO recognizes that DOD has done much to anticipate and manage risk in the AIM-9X development program. In GAO's view, however, DOD is willing to enter production with many unknowns. As DOD stated in its comments, a basic tenet of the AIM-9X program is that all elements of the AIM-9X system are necessary to eliminate the disadvantage currently faced by U.S. warfighters. Yet, in its response, DOD states that, if the aircraft radar were used for cueing purposes, the AIM-9X—even without the helmet-mounted cueing system—offers an increased capability against fielded threat systems. It is important to note, however, that to take advantage of this potential capability, pilots would be required to follow yet to be developed procedures and tactics that would be considerably different than current practices for aerial combat. Moreover, DOD officials GAO spoke with agreed that it is questionable whether DOD can meet its own positive identification

requirement using the aircraft radar for cueing purposes. In addition, at this time of limited defense resources, GAO continues to believe that specific consideration of coordinated funding and production plans at the low-rate initial production decision point is necessary to ensure that all elements of the AIM-9X system, once tested, are produced and deployed together.

DOD's entire comments on the draft report are included in appendix I. DOD's specific comments and GAO's evaluation appear at the end of each report chapter.

Contents

Abbreviations

ASRAAM	Advanced Short-Range Air-to-Air Missile
DOD	Department of Defense

Introduction

The AIM-9 family of air-to-air missiles has protected U.S. fighter aircraft for over 40 years, but now there are more modern foreign missiles that may present a threat to U.S. aircraft. The U.S. Navy and Air Force considered buying a foreign missile but determined that the best solution to meet U.S. requirements was to extensively upgrade the current AIM-9M missile. The services selected Hughes Missile Systems Company (now the Raytheon Corporation) to develop and produce a very maneuverable missile that, together with a new helmet-mounted cueing system, is expected to be the best in the world.

The AIM-9M Is No Longer the Best Short-Range Missile in the World

The AIM-9 Sidewinder family of air-to-air missiles is carried on all tactical fighter aircraft and is used at short ranges when target aircraft are too close for radar-guided missiles to be effective. The Sidewinder was first deployed in the 1950s—as the AIM-9B. Over the years, improvements were made as new models were introduced. The missiles have been sold to many friendly countries. The current missile, the AIM-9M, evolved in 1978. U.S. fighter aircraft equipped with the AIM-9M missile, however, are facing modern foreign-built missiles and advanced cueing/targeting systems.

The rules of engagement for U.S. pilots require that, in many situations, they make a positive identification before firing on an adversary. This results in the pilot's not being able to fire until the target aircraft is well within visual range. At combat speeds such an encounter can quickly evolve into a close-in fight,[1] during which a short-range missile is required. A joint Navy and Air Force study predicts that a significant percentage of air-to-air encounters will result in a close-in flight.

In April 1996, the Air Force Chief of Staff testified that U.S. pilots have the fourth best short-range missile in the world. Modern short-range missile systems with their cueing/targeting systems can engage targets throughout the forward hemisphere of the aircraft, providing a decisive advantage in a close-in fight. The services are trying to develop tactics and countermeasures to neutralize these threats, but there is general agreement that a more capable U.S. short-range missile system is needed as soon as possible.

[1]In "close-in fight," combatants are within visual range of each other.

Foreign-Made Missiles Do Not Meet U.S. Requirements

In the 1970s, the United States and several European countries signed a Memorandum of Agreement that specified that the Europeans would develop a new short-range missile to replace the AIM-9 Sidewinder series. That missile became the Advanced Short-Range Air-to-Air Missile (ASRAAM). In the late 1980s, however, the European consortium dissolved. When the consortium dissolved, the Navy and the Air Force reexamined U.S. requirements and determined that the ASRAAM did not have the capability they required. The United States subsequently left the ASRAAM program. The two services then worked on separate upgrades to the AIM-9M. After false starts with their separate programs, a joint Navy and Air Force program with the Navy as lead service was started to extensively upgrade the AIM-9M. The upgraded missile is the AIM-9X.

As a part of the alternative evaluation process before starting the AIM-9X program, the services considered acquiring one of the modern foreign missiles such as the Russian AA-11, the Israeli PYTHON 4, or the British ASRAAM as an alternative to developing a new U.S. missile. DOD determined, however, that none of these missiles was able to meet all of the U.S. requirements.

The services conducted an evaluation of the ASRAAM, including a 6-month Foreign Comparison Test that included firing the missile from a U.S. F-16 aircraft. The ASRAAM is electrically and physically compatible with U.S. aircraft and uses the same infrared sensor as the AIM-9X. The evaluation, however, showed that ASRAAM does not meet all of the U. S. performance requirements. Also, the evaluation showed that, because of the additional time and cost that would be needed to upgrade, test, and integrate ASRAAM for U.S. aircraft, it offered no advantage over the proposed AIM-9X missile.

The AIM-9X Weapon System Is to Have Enhanced Capabilities

During the 2-year AIM-9X concept development phase, the services analyzed user needs, current and future threats, and available technology to determine the requirements for the new missile. The resulting AIM-9X system requirement has five key performance parameters:

- the ability to operate during the day or at night;
- the ability to operate over land and at sea in the presence of infrared countermeasures;
- weight, size, and electrical compatibility with all current U.S. fighters and the F-22;
- the ability to acquire, track, and fire on targets over a wider area than the AIM-9M; and

- a high probability that a missile launched will reach and kill its target.

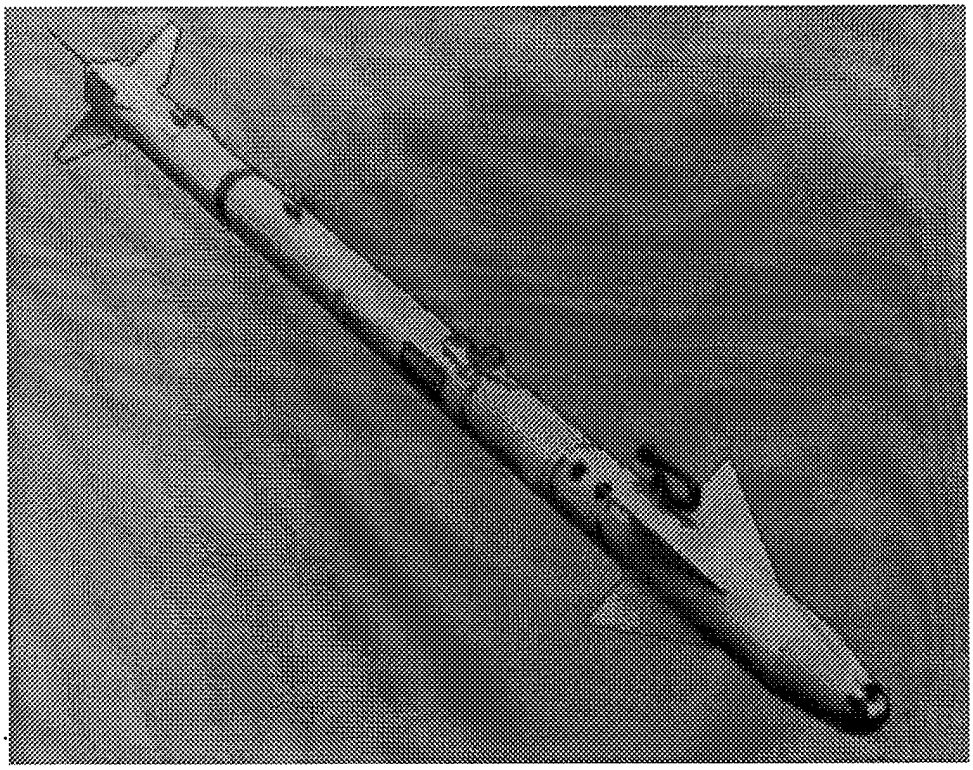
The analyses showed that user requirements could be met and that technical risk could be reduced, by modifying the existing AIM-9M and developing a new targeting/cueing system.

The AIM-9X missile is planned to have increased resistance to countermeasures and improved target acquisition capability over the AIM-9M. It will have a new infrared seeker, a tracker to interpret what the seeker sees, a streamlined missile body, and rocket motor thrust vectoring for improved maneuvering. It will be carried on all U.S. fighter aircraft, including the F/A-18, F-15, F-16, and F-22.

An 18-month AIM-9X competitive demonstration and validation program began in 1994 with the Hughes Missile Systems Company and the Raytheon Corporation as the competing contractors. Both companies demonstrated, among other things, how they would reduce the technical risk of developing the AIM-9X missile. Examples of demonstration and validation work include trade studies, simulating missile performance, analyzing missile compatibility with Navy and Air Force aircraft, and flight testing target-tracking capability. Additionally, the contractors were required to plan for manufacturing the missile, including identifying new or unique processes and special tooling and facilities requirements. Hughes was selected as the AIM-9X missile contractor in December 1996.

Hughes has total performance responsibility, including development, production, and maintenance support for the missile. Engineering and manufacturing development began in January 1997 and is planned to end in 2001. The services plan to buy a total of 10,000 missiles at an average unit cost of $264,000 (then-year dollars). The AIM-9X missile is shown in figure 1.1.

Figure 1.1: AIM-9X Short-Range Air-to-Air Missile



Source: Hughes Missile Systems.

A separate, parallel program is developing a helmet-mounted cueing system that would allow U.S. pilots to aim the AIM-9X missile seeker toward a target aircraft by turning their heads and looking at the target. The pilot can then fire the missile without having to turn the aircraft toward the target, increasing the probability of killing a hostile aircraft before it can launch a missile. Another effort is developing the necessary hardware and software modifications to integrate the missile and helmet into the aircraft. All three elements of the AIM-9X weapon system—the missile, helmet, and aircraft modifications—are seen as critical to countering the capabilities of modern threat missiles.

Objectives, Scope, and Methodology

The Chairman, Subcommittee on Military Research and Development, House Committee on National Security, requested that we provide an independent assessment of the AIM-9X program's status. Our objectives were to determine (1) the services' efforts to reduce missile development risk, (2) the missile program's plan to transition from development to production, and (3) the importance of separately managed but essential supporting systems.

To evaluate the missile's development risk, we visited the program office and the contractor where we discussed technology and schedule risk. We reviewed the program acquisition and test plans. We visited the Naval Air Weapons Center at China Lake, California, where we discussed the missile program's technology and schedule with the government short-range missile experts. We reviewed reports prepared by the contractors during the program demonstration and validation phase. We also reviewed several studies of foreign missiles, including the Senior Review Team analysis of the ASRAAM program.

To assess the missile program's plan to transition from development to production, we examined the planned development and operational test schedules and production plans. We considered the amount and type of testing that is planned to be accomplished before the first and subsequent production decisions. We discussed test plans and potential risks with program, contractor, and DOD officials charged with managing and overseeing missile flight testing. We also reviewed our previous reports on other major acquisition systems with regard to readiness to enter low-rate initial production.

We reviewed the helmet-mounted cueing system, a separately managed but essential supporting system, to determine its importance to the AIM-9X system. We discussed program technical issues with program managers. We also compared schedule plans for the AIM-9X missile, helmet-mounted cueing system, and associated aircraft modifications.

During the course of this review, we met with representatives from the DOD Inspector General, Naval Air Systems Command, and Air Force Headquarters, Washington, D.C.; Commander in Chief, Atlantic Fleet, Norfolk, Virginia; Naval Air Weapons Center, China Lake, California; Air Combat Command, Langley Air Force Base, Virginia; Aeronautical Systems Center and National Air Intelligence Center, Wright-Patterson Air Force Base, Ohio; ASRAAM Senior Review Team, Baltimore, Maryland; and Hughes Missile Systems Company, Tucson, Arizona.

We performed our audit between July 1996 and October 1997 in accordance with generally accepted government auditing standards.

Strategies to Reduce Missile Technical, Cost, and Schedule Risks

The AIM-9X missile development program is designed to balance the requirements for a more capable short-range missile with the users' limited resources and the need to field the new missile as soon as possible. Key elements of the approved development plan are strategies to reduce technical risk and incentives to lower cost and ensure schedule performance. By early 1999, when the AIM-9X missile design is expected to be finalized and flight tests are underway, a more accurate assessment of the program status can be made.

Strategies to Reduce Technical Risk

Technology problems are often the cause of cost growth and schedule delays in development programs. To help ensure a successful AIM-9X missile development program, the services have adopted several strategies to minimize technical risk. Among these are:

- using existing subsystems, components, and items not requiring development;
- conducting a competitive demonstration and validation of new technology; and
- combining government and contractor technical expertise through integrated product teams.

The AIM-9X missile will use some existing subsystems that do not require development. For example, several key components are identical to those used in the AIM-9M missile, including the warhead, rocket motor, and fuze. These components satisfy user requirements and can be obtained either from existing inventory missiles or from new production. In either case, the design and production processes for these items are tested and proven.

The winning Hughes missile design also includes many nondevelopmental items. For example, Hughes will use fins, an airframe, and an engine control system previously developed and tested by the Air Force. The cryoengine, which cools the missile sensor, is a modified version of a similar device used in other systems. These components do not require lengthy development and testing but will require some modification for the AIM-9X. Hughes officials told us that over 70 percent of the missile design uses parts that do not require development. The company also estimates that 66 percent of AIM-9X missile software can be obtained from existing programs.

To help anticipate, identify, and solve technical problems, the government's technical experts in short-range missile development have

been added to the Hughes AIM-9X development team as a part of the integrated product teams concept. Technical experts from the Naval Air Warfare Center at China Lake, California, and the Aeronautical Systems Center at Eglin Air Force Base, Florida, are now a part of the AIM-9X team. Under this teaming approach, the combined knowledge and efforts of both contractor and government are focused on the development process.

Hughes has also implemented a comprehensive technical risk assessment system that identifies and tracks all known technical risks in the program. Each risk is described, quantified, monitored, and reported. For example, Hughes has assessed the guidance and control and thrust vectoring system as moderate to low-risk items. The company has developed management plans to address these risks.

Strategies to Reduce AIM-9X Cost

Affordability is a central objective of the AIM-9X missile program. The emphasis on cost began during the requirements definition process, continued through the demonstration and validation phase, was a factor in the selection of the development contractor, and is an integral part of the program acquisition strategy. As a DOD flagship program for the Cost as an Independent Variable Initiative—under which cost is considered more as a constraint and less as a variable—the AIM-9X program has incorporated a series of acquisition reforms to focus both government and contractor efforts to reduce and control program costs.

As a program objective, AIM-9X affordability is second only to achieving the missile's key performance characteristics. Low cost was and remains one of the users' critical requirements for the system. During the concept development phase, an assessment of needed capabilities and anticipated cost considered the projected threat, available and emerging technologies, and projected resources. Performance and cost trade studies identified the minimum essential performance requirements and determined they could be obtained at an acceptable cost if the AIM-9M was upgraded with a new sensor and airframe instead of developing an entirely new missile.

Reducing AIM-9X missile development and production cost and obtaining high confidence in the contractors' cost estimates and cost management approach were key objectives of the 18-month demonstration phase. Under the competitive pressure of the winner-take-all development contract, the government required the contractors to establish design-to-cost goals and implementation plans, conduct affordability and

producibility studies, and propose a production quantity and price structure. According to the program manager, this emphasis on cost control and cost management both reduced the expected cost of the program and increased the program office's confidence that the contractor's development and production cost proposal was sound and likely to be achieved.

Eight initiatives were pursued during the demonstration phase to reduce program costs with only minor changes to the system's performance requirements resulting in an estimated cost avoidance of $1.2 billion. Examples of successful reductions include relaxing computer processing time requirements (which eliminated one circuit board) and standardizing missile seeker cooling methods (which eliminated the need for two different cooling systems).

Strategies to Ensure Schedule Performance

The AIM-9X missile program has adopted several strategies to establish a realistic and achievable development schedule that provides the first missiles to Navy and Air Force fighter units as soon as possible. Principal among these strategies is the requirement that Hughes develop and follow a detailed integrated master plan and master schedule.

The program manager told us that the government strategy for reducing schedule risk on the AIM-9X program has been to encourage the contractor to develop and follow soundly based development plans. Accordingly, both contractors were required to develop and submit integrated master plans and schedules for development and low-rate initial production during the demonstration phase.

Following the successful demonstration phase, Hughes and the missile program office reexamined the proposed development schedule. On the bases of that reexamination, they agreed to reduce the development schedule from 68 to 61 months and to begin low-rate initial production a year earlier, thereby lowering development cost by $35 million. This reduction, according to the program manager, was made possible by the Hughes comprehensive development and test schedule.

Conclusions

The AIM-9X missile development program contains a series of strategies to reduce technical risk and incentives to lower cost and ensure schedule performance. Whether program efforts to reduce technical, cost, and schedule risk will succeed will not be known for at least another year. Both program and contractor officials told us that most of the AIM-9X missile development will be completed by the spring of 1999. At that time, the AIM-9X design will be finalized, assembly of engineering development missiles underway, and development flight testing in process. The missile program manager believes any remaining development risk will be well understood at that time.

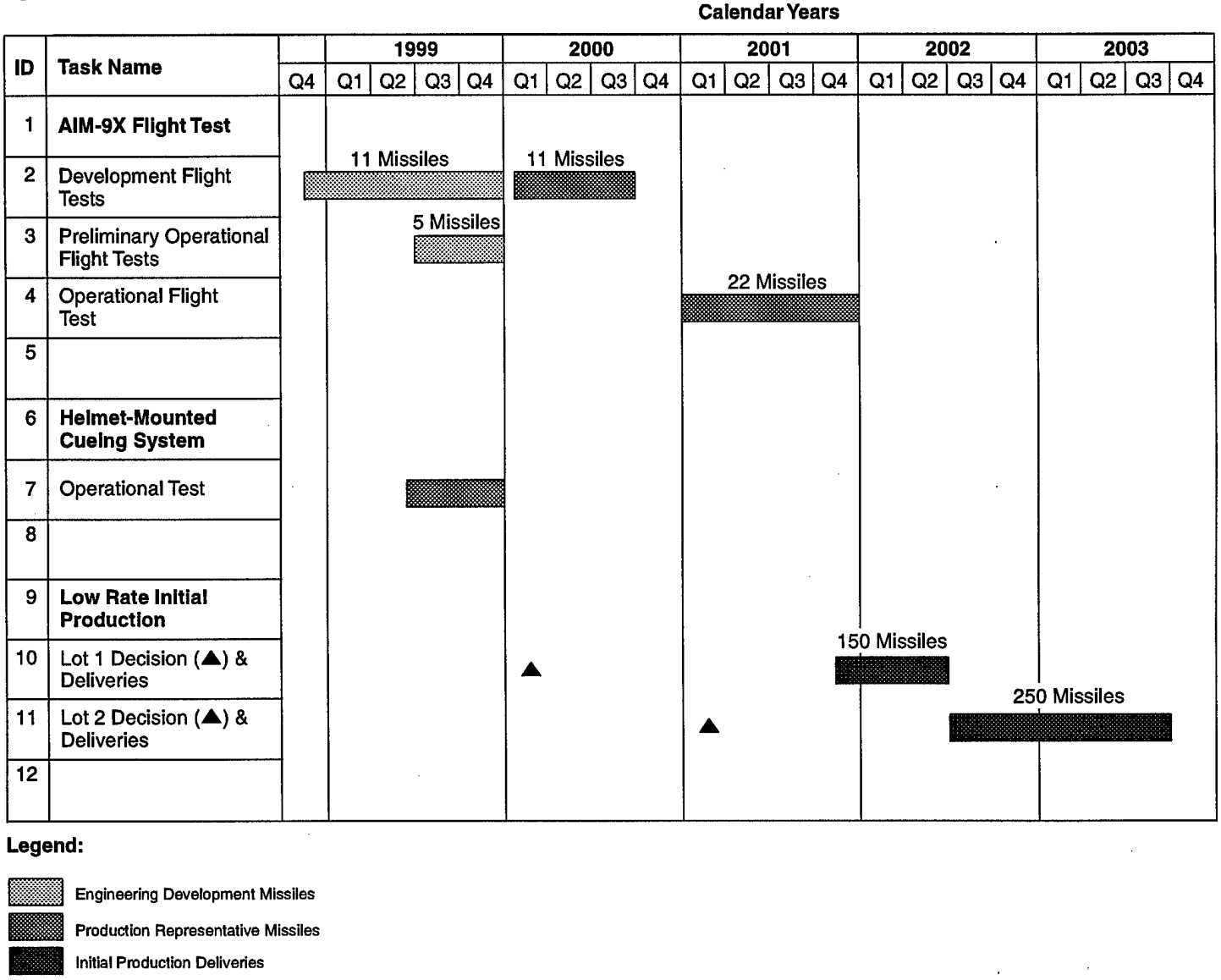
AIM-9X Missile Low-Rate Initial Production Appears to Be Premature

In an effort to initiate AIM-9X missile production as soon as practical, the services plan to make the low-rate initial production decision in early 2000. This production decision is to be made before completing development flight tests, before adequately testing production representative missiles, and before full operational testing begins. This plan risks later discovery of problems requiring design changes and the associated cost, schedule, and performance impacts. We believe initiating low-rate initial production before developmental flight testing is complete and before there is some operational testing with production representative missiles adds unnecessary risk to the production program.

Low-Rate Initial Production Planned Before Testing of Production Representative Missiles

The services plan to begin AIM-9X missile low-rate initial production in early 2000 by exercising the first production contract option for 150 missiles. A year later, the second production contract option for 250 missiles is to be exercised. Figure 3.1 shows the program's planned test and production decision schedule.

Figure 3.1: AIM-9X Flight Test and Low-Rate Initial Production Schedule



Source: AIM-9X Program Office.

As figure 3.1 shows, the low-rate initial production decision for the AIM-9X missile is to be made about 1 year before completion of the planned

developmental flight test program. All of the flight tests to be conducted before the missile low-rate initial production decision, including those to be conducted as part of the preliminary operational testing, will use engineering development missiles. These missiles are manufactured early in the development program and represent the contractor's design before any significant flight testing begins. These flight tests will also use development level software and may not incorporate the helmet until the last several flights.

Later in the development program, changes to the missile design are likely as the test results and manufacturing improvements are incorporated in production representative missiles. These test missiles are intended to be very close in physical configuration and performance to the AIM-9X production missile. They are to be used during the last phase of the developmental flight tests and for all of the operational flight tests.

Flight Testing to Continue for 2 Years After Start of Low-Rate Initial Production

Developmental and independent operational flight testing using production representative missiles is scheduled to begin at about the same time as the low-rate initial production decision and continue for about 2 years. These tests expand upon earlier developmental testing, verify design changes incorporated in the production representative missiles, and focus on the system's operational effectiveness and suitability.[1] These test results, however, will not be available until after low-rate initial missile production begins, with most operational flight tests occurring after the second missile production contract is exercised. Indeed, the first low-rate initial production missiles are expected to be delivered before the operational testing is complete.

The significant body of developmental and operational flight testing planned after the low-rate initial production decision point is important to realistically demonstrate and assess the AIM-9X weapon system's ability to meet its minimum acceptable requirements for performance and suitability without major or costly design changes. Should problems be disclosed in these tests necessitating changes to the missile design, the missile cost, schedule, and performance may be adversely affected. Moreover, because

[1]DOD defines "operational effectiveness" as the overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, tactics, survivability, vulnerability, and threat. DOD defines "operational suitability" as the degree to which a system can be placed satisfactorily in field use with consideration given to such factors as availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, and supportability.

the low-rate initial production missiles are to be deployed directly to operational units, such changes would directly affect operating units.

Recommendation

We recommend that the Secretary of Defense direct the Secretaries of the Navy and the Air Force to revise the AIM-9X missile's acquisition strategy to allow for the completion of all developmental flight tests and enough operational flight tests with production representative missiles to demonstrate that the missile can meet its minimum performance requirements before low-rate initial production begins.

Agency Comments and Our Response

DOD did not concur with the recommendation, stating that adequate testing is planned prior to the low-rate initial production decision for an informed decision.

The performance data to support the low-rate initial production decision will be based on incomplete testing of developmental missiles and software. Flight testing of the production representative missiles and associated systems is scheduled to begin more than a year after the planned production decision. As we have reported previously, many of the weapon systems that start production without performing operational tests to gain assurance that the systems will perform satisfactorily later experience significant operational effectiveness and/or suitability problems.[2]

[2]Weapons Acquisition: Low-Rate Initial Production Used to Buy Weapon Systems Prematurely (GAO/NSIAD-95-18, Nov. 21, 1994).

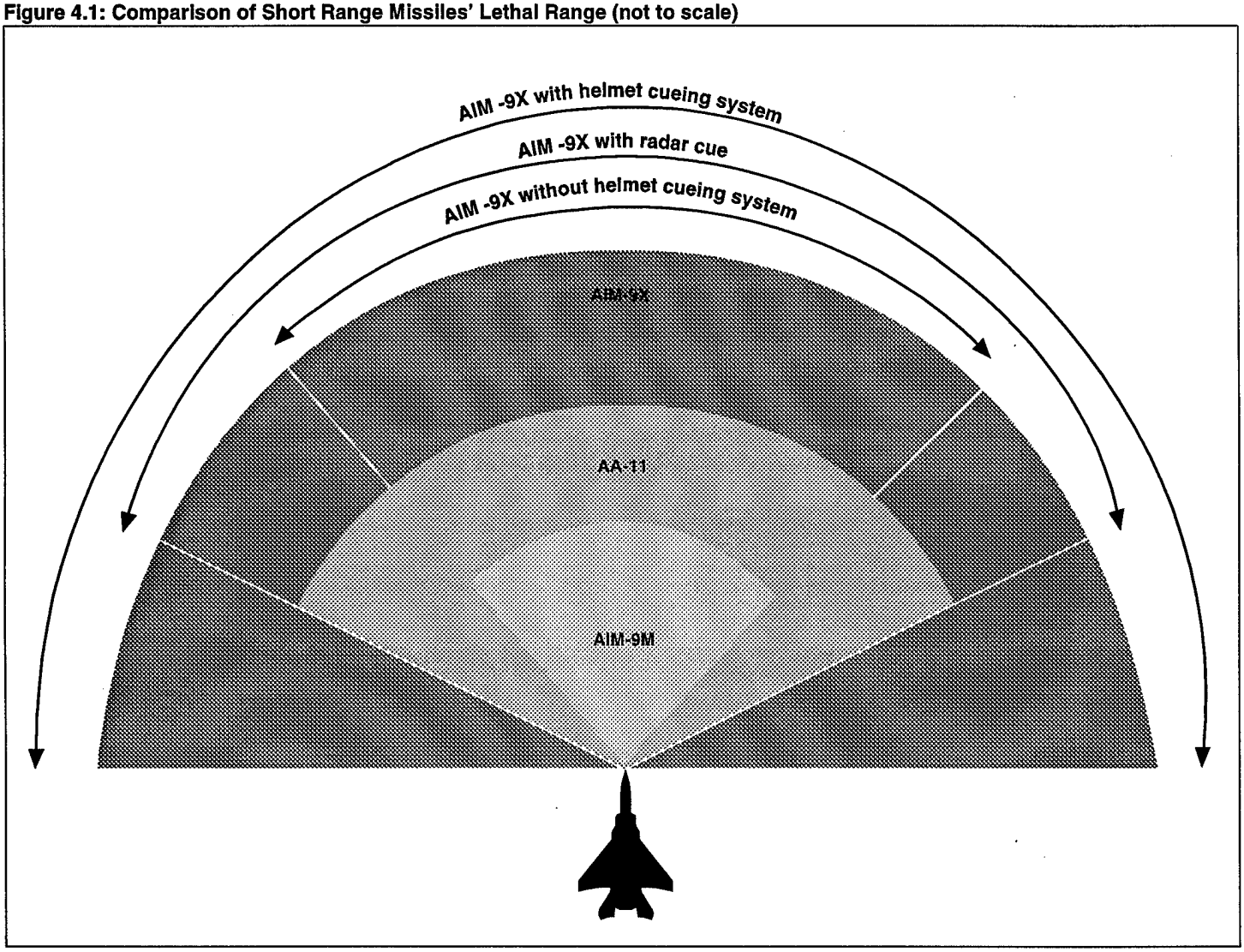
AIM-9X System of Systems Needs to Be Tested, Produced, and Deployed Together

All three elements of the AIM-9X weapon system—the missile, the helmet-mounted cueing system, and the associated aircraft modifications—must be present and properly working together to ensure that U.S. fighters can prevail against modern threat missiles. The services are closely coordinating the separate development programs and plan to test all of the elements together during AIM-9X flight testing. However, there is no requirement that production representative versions of the missile, helmet, and associated aircraft modifications be successfully demonstrated together before the AIM-9X missile goes into low-rate initial production. Moreover, helmets and associated aircraft modifications are not linked to the approved AIM-9X missile production and funding plans. By not requiring that the missile, helmet, and aircraft modifications be tested, produced, and deployed together, as a "system of systems," DOD risks fielding a missile unable to prevail in aerial combat.

All Elements Are Needed to Field a Superior System

To help them prevail in the close-in air battle, U.S. pilots are going to need not only the AIM-9X missile, but also the helmet and associated aircraft modifications. The Russians and Israelis have already developed, produced, and deployed short-range missile systems with helmet-mounted cueing systems. The Russian AA-11 missile and helmet system have been widely exported. The British, French, and other nations are also developing modern missiles. While the AIM-9X missile with the helmet is expected to be superior to all of them, the missile alone is not. Figure 4.1 illustrates the relative capabilities of the AIM-9X system of systems, the AA-11, and the AIM-9M, which is currently operational.

Figure 4.1: Comparison of Short Range Missiles' Lethal Range (not to scale)



Source: Hughes Missile Systems.

Service officials told us that the rules for engaging enemy aircraft and the requirement for positive identification of targets increase the likelihood of close-in air battles in the future. While the AIM-9X and other missiles can be used at longer ranges, the positive identification requirement, together with the speed and agility of modern fighter aircraft, can quickly transform the fight into a close-in air battle where the advantage is held by the aircraft that can lock-on to its adversary and shoot first.

As figure 4.1 shows, the AIM-9X missile without a helmet is expected to have greater lethal range than the AIM-9M and the AA-11. Without the helmet, however, a U.S. pilot would be unable to take full advantage of the AIM-9X capability to take the critical first shot that often determines the survivor in a close-in air battle. This first shot capability is achieved by the combination of the (1) helmet and the missile sensor acquiring a target well off to the side of the aircraft, as well as in front of it and (2) computer software that links the pilot's helmet, the missile, and the aircraft fire control system. As shown in the figure, the AIM-9X system (missile, helmet, and aircraft modifications) is expected to have a distinct advantage over the AA-11 missile.

In commenting on a draft of this report, DOD stated that the projected range and sensor tracking capability of AIM-9X without the helmet-mounted cueing system is equivalent to the capability of the AA-11 threat missile in azimuth and exceeds the capability of the AA-11 in range. DOD's position is based on using the fighter aircraft radar to cue the AIM-9X missile to the target of interest when it is beyond the view of the aircraft's heads-up display. Using the radar to cue the missile, however, will take more time and be less certain than with the helmet and will require DOD to train pilots in yet to be developed procedures and tactics that would be considerably different than current practices for aerial combat. Moreover, DOD officials we spoke with agreed that it is questionable whether DOD can meet its own positive identification requirement using the aircraft radar for cueing purposes.

Development Programs Are Separate but Closely Coordinated

The AIM-9X missile, helmet, and associated aircraft modifications are being developed under separate but closely coordinated programs. The missile and helmet contractors have negotiated detailed working agreements to ensure the missile, helmet, and aircraft modifications are developed to operate together and to be fully compatible with both Navy and Air Force aircraft. While each development program will test its system independently, the missile, helmet, and aircraft modifications are also planned to be tested together as a part of AIM-9X missile flight testing.

An early operational assessment of the combined system, including five flight tests, is planned prior to the AIM-9X low-rate initial production decision. Then, for the next 2 years, production representative missiles, helmets, and aircraft software are to be tested under both developmental and realistic operating conditions.

While plans are in place to perform total system testing with the missile, helmet, and aircraft modifications prior to the initial AIM-9X missile low-rate initial production decision, those tests will not be done using production representative hardware and software. Moreover, there is no formal requirement that sufficient total system testing take place prior to starting missile low-rate initial production to demonstrate that the AIM-9X weapon system can meet its key performance parameters. We are concerned about this because of the criticality that all three elements work together to ensure that the AIM-9X system will prevail against modern threat missiles. If technical problems delay development of the helmet or aircraft modifications, missile testing will proceed to support the low-rate initial production decision. At that time, the ability of the AIM-9X system to achieve its performance parameters will not be known.

Production Plans and Funding Are Not Fully Coordinated

There is an approved and funded AIM-9X production plan to acquire 10,000 missiles over 18 years beginning in 2000; however, no such production plan or approved funding exists for the helmet or for the associated aircraft modifications. We were told by the helmet program manager that each of the aircraft program offices must plan and budget for helmets and associated modifications consistent with their needs and resources.

Conclusions

All elements of the AIM-9X weapon system must be in place to achieve the program's objective, which is to ensure that Navy and Air Force fighters prevail in close-in aerial combat. Without a requirement that all elements of this system of systems be tested together, produced together, and deployed together, the full capability of the system will not be realized. Until the weapon system is tested and evaluated using production representative missiles and helmets, DOD decisionmakers will not have information on whether the AIM-9X weapon system's key performance parameters are achievable.

Recommendations

We recommend that the Secretary of Defense direct the Secretaries of the Navy and the Air Force to revise the AIM-9X missile acquisition strategy to allow for enough operational testing of the missile, helmet, and associated aircraft modifications to be accomplished, using production representative hardware and software, to demonstrate that the AIM-9X system can meet its minimum performance requirements before low-rate initial production begins. We also recommend that the Secretary of Defense direct the services to provide a coordinated production, deployment, and funding plan for all three elements of the system.

DOD Comments and Our Response

On the first recommendation, DOD did not concur and stated that significant improvement over the current operational system is possible with just the AIM-9X missile only. DOD added that it would not be prudent to delay the missile development and testing to provide concurrent development and test demonstration with the helmet and aircraft modifications. On the second recommendation, DOD partially concurred and stated that it would continue to coordinate all three elements of the system but would not formally tie the three elements together. DOD expressed concern that insisting that the schedules for the missile, helmet, and aircraft modifications remain synchronized risks burdening it with higher costs if one element falls behind schedule and the other elements have to proceed at a reduced, inefficient level.

The objective of the AIM-9X program has been to develop a system that will provide the capability to prevail in aerial combat against modern threat missiles. Using the missile without the helmet will not provide that capability and will require DOD to train pilots in yet to be developed procedures and tactics that would be considerably different than current practices for aerial combat. Although there are risks in continuing to synchronize the helmet and missile schedules, we believe that DOD would be accepting more risk than necessary by committing to low-rate initial production of the missiles before demonstrating, using production representative hardware and software, that the total AIM-9X system can meet its minimum performance requirements.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

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ACQUISITION AND TECHNOLOGY

16 JAN 1998

Mr. Louis J. Rodrigues
Director, Defense Acquisition Issues
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Rodrigues:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) Draft Report, "AIM-9X ACQUISITION: Missile Risk Reduction Underway but System Production Plans need to be Reexamined," dated December 9, 1997 (GAO Code 707185), OSD Case 1502. The three recommendations made by the GAO fail to recognize the degree to which risk will be characterized and mitigated prior to the Low-Rate Initial Production (LRIP) decision on AIM-9X.

The Department believes the risks associated with AIM-9X development are well-characterized and mitigation plans are in place to address these risks. Current plans provide adequate testing prior to the LRIP milestone for an informed decision to be made by the Defense Acquisition Executive. The major subsystems for AIM-9X--the warhead, the rocket motor, and the target detector--will have been in production and operational use for almost two decades prior to the LRIP decision. The tail-controlled airframe results from work begun in the late 1980s, and it has already been successfully test-fired 14 times. The primary area of risk is in software development and verification. Plans are in place to assure that the software has been thoroughly tested and evaluated by independent Service and Office of the Secretary of Defense operational testers prior to the LRIP review.

Although it is true that all elements of the AIM-9X weapon system are necessary for the full capability of the system to be realized, significant improvement over the current operational system is possible with the AIM-9X missile only. The warfighters are currently at a disadvantage against a number of fielded threat systems. Even without the helmet-mounted cueing system (HMCS), the AIM-9X missile represents a major step in countering these threats. Therefore, it is imperative that fielding of the AIM-9X missile not be delayed even if there is a future schedule incompatibility with the HMCS.

Currently, the schedules for the missile, the HMCS, and the aircraft operational flight programs (OFPs) are synchronized. However, insisting that they all remain synchronized--if, for example, the helmet or missile schedule slips--would burden the Department with unnecessary additional costs of keeping one systems contractor and

government team at a reduced, inefficient work level, while the other completes its final work.

Although there is no formal requirement to tie these programs together, the Department agrees that it is extremely important to achieve the maximum benefits from the capability provided by the integration of these three efforts. Weekly meetings are held between the contractors for all systems and the government program offices; monthly reviews by the program manager; and quarterly reviews by the helmet, missile, and aircraft Program Executive Officers, and the Navy and Air Force Acquisition Executives. The Department will enhance its efforts on the formal planning, execution, and review of the developmental progress of these programs as independent systems and in joint use, to ensure they are fielded as an integrated system as quickly as possible.

The attachment addresses the specific GAO recommendations in more detail. Recommended editorial corrections to the draft report were provided separately. The Department appreciates the opportunity to comment on the draft report.

George R. Schneiter
Director
Strategic and Tactical Systems

Attachment

GAO DRAFT REPORT DATED DECEMBER 9, 1997
(GAO CODE 707185), OSD CASE 1502

"AIM-9X ACQUISITION: Missile Risk Reduction Underway but System Production Plans Need to be Reexamined"

DEPARTMENT OF DEFENSE COMMENTS

****

RECOMMENDATIONS

Recommendation 1: The GAO recommended that the Secretary of Defense direct the Secretaries of the Navy and the Air Force to revise the AIM-9X missile's acquisition strategy to allow for the completion of all developmental flight tests and enough operational flight tests with production representative missiles to demonstrate that the missile can meet its minimum performance requirements before low-rate initial production begins. (p. 7, p. 24/GAO Draft Report)

Now on pp. 6 and 23.

DoD Response: **Nonconcur.** The risks associated with AIM-9X development are well-characterized, and mitigation plans are in place to address these risks. The Department believes there is adequate testing planned prior to the low-rate initial production (LRIP) milestone for an informed decision to be made by the Defense Acquisition Executive. The major subsystems for AIM-9X--the warhead, the rocket motor, and the target detector--will have been in production and operational use for almost two decades prior to the LRIP decision. The tail-controlled airframe results from work begun in the late 1980s, and it has already been successfully test-fired 14 times. The primary area of risk is in software development and verification. Plans are in place to assure that the software has been thoroughly tested and evaluated by independent Service and Office of the Secretary of Defense operational testers prior to the LRIP review. Stringent LRIP exit criteria have been established, to include manufacturing, reliability, and cost criteria. In addition, after the operational firings of the five missiles that support the LRIP decision, but prior to the decision, the test schedule calls for the firing of two production-representative missiles.

See comment 1.

Recommendation 2: The GAO also recommended that the Secretary of Defense direct the Secretaries of the Navy and the Air Force to revise the AIM-9X acquisition strategy to allow for enough operational testing of the missile, helmet-mounted cueing system (HMCS), and associated aircraft modifications to be accomplished, using production representative hardware and software, to demonstrate that the AIM-9X system can meet its minimum performance requirements before low-rate initial production begins. (p. 7, p. 29/GAO Draft Report)

Now on pp. 6 and 28.

Now on p. 25.
See comment 2.

DoD Response: **Nonconcur.** Although it is true that all elements of the AIM-9X weapon system are necessary for the full capability of the system to be realized. significant improvement over the current operational system is possible with just the AIM-9X missile only. The Department does not believe it is prudent to delay the missile development and testing to provide concurrent development and test demonstration with the HMCS and operational flight programs (OFPs).

The graphic on page 26 of the draft report is incorrect. Although it is not to scale to prevent disclosure of classified information, the range and sensor tracking capability of AIM-9X without the HMCS is equivalent to the capability of the AA-11 threat missile in azimuth, and exceeds the capability of the AA-11 in range. The Department is making every effort to ensure there is synergistic development, test, and integration of the AIM-9X missile, HMCS, and aircraft OFPs. However, because the warfighters are already at a disadvantage against a number of fielded threat systems, it is imperative that fielding of the AIM-9X missile not be delayed even if there is a future schedule incompatibility with the HMCS.

See comment 3.

Currently, the schedules for the missile, the HMCS, and the aircraft operational flight programs (OFPs) are synchronized. However, insisting that they all remain synchronized--if, for example, the helmet or missile schedule slips--would burden the Department with unnecessary additional costs of keeping one systems contractor and government team at a reduced, inefficient work level, while the other completes its final work. The HMCS-missile combination provides the full needed capability. Tying of the OFP to either the helmet or the missile is not logical since there are multiple improvements addressed in the bi-annual OFP that addresses aircraft avionics improvements and other high-priority weapons.

Now on pp. 6 and 28.

Recommendation 3: The GAO further recommends that the Secretary of Defense direct the Services to provide a coordinated production and funding plan for all three elements of the system. (p. 7, p. 29/GAO Draft Report)

DoD Response: **Partially concur.** Although there is no formal requirement to tie these programs together, there is a great deal of formal planning, execution, and review of the developmental progress of these programs as independent systems and in joint use. Weekly meetings are held between the contractors for all systems and the government program offices; monthly reviews by the program manager; and quarterly reviews by the helmet, missile, and aircraft Program Executive Officers, and the Navy and Air Force Acquisition Executives. The Department agrees it is important to achieve the advantages of the integrated systems capability as soon as practical. Therefore, the Department will continue to emphasize the coordination and review efforts among these programs at the Service and OSD staff levels to ensure concurrent fielding of the capabilities, if possible.

Following are our comments on the Department of Defense's (DOD) letter dated January 16, 1998.

GAO Comments

1. The last AIM-9X schedule that we reviewed indicated that one test firing of a production representative missile is planned to occur within days of the low-rate initial production decision. Should these two development (vice operational) tests be accomplished as DOD now proposes, the detailed assessment of the test results will not be available to decisionmakers.

2. Figure 4.1 has been modified to indicate the potentially greater level of lethal azimuth of the AIM-9X when the missile is cued by the aircraft radar. However, that radar cueing of the missile is neither as fast nor as certain as with the helmet. Also, procedures and tactics for using the radar cueing capability with the AIM-9X would have to be developed and pilots would have to be trained.

3. Our recommendation addresses only those aircraft modifications needed to integrate the AIM-9X missile and the new helmet into each aircraft. Other aspects of the operational flight program should not be affected.

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